Glass as an active component of functional materials

An invited talk

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Functional glass is the glass exhibiting special physical and chemical performances for various advanced applications. Today many scientists are developing and studying new generations of functional glasses, e.g. photonic, magnetic, conductive, biological glasses. Most of these studies focus on design of glass compositions or post-treatment of glasses under various conditions. However, there are many promising possibilities for glass to be used as an active component in other types of functional materials. This aspect is attracting the attention of scientists. Here we describe this aspect by using some of our recent studies as examples.

(1) Glass is utilized to enhance the chemical reactivity and mechanical performances in cementations materials. The CO_2 emission of cement production is greatly reduced by substituting a mixture of well-designed glass powder and lime powder for part of clinker. At the same time, both pozzolanity and compressive strength of cement are enhanced [1]. We also investigate dental cement consisting of glass powder and polymer with respect to its fracture toughness and bioactivity during setting [2]. It is found that the fracture toughness of the dental cement changes non-monotonically with setting time. Such a change is governed by the interface structure between glass and polymer. Using differential scanning calorimetry (DSC) and Nuclear Magnetic resonance we found that the fracture toughness and reactivity of the cement depend on the chemical composition, structure, phase separation, and post-treatment of glass powder.

(2) Disorder concept is applied to improve the performances of lithium ion batteries. The disordered nanostructure provides sites for storing Li^+ ions and easier transfer kinetics of electrons and lithium ions, and displays the superior discharge capacity and an ultra-high coulombic efficiency [3].

(3) Glass is made nanoporous and bioactive to effectively immobilize enzymes for enhancing their catalytic activity [4]. This glass proves to be a crucial component of functional bio-systems, which enables enzyme more efficient for bioconversion, bioremediation, biosensors and drugs.

(4) A new approach is discovered for fabricating polyamorphic organic/inorganic hybrid glasses from a single metal-organic framework (MOF) using DSC. The new approach is based on a well-controlled dynamic heating and cooling processes. Even bulk MOF glass is obtained by cooling the hybrid liquid. This offers an industrially feasible route to functional hybrid glasses from metal-organic frameworks, and gives new ways to understanding the polyamorphic transition and its relation to liquid fragility in MOF materials.

(5) Glassy thin film is generated on a substrate to fabricate membrane devices [5]. It is the glassy film that offers multi-functionalities to membrane. Thus, the glassy film is an active component of functional devices.

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